Title: Method for enhancing methane production from coal seams by inducing matrix shrinkage and placement of a propped fracture treatment

References Cited:

U.S. Patents

6,571,874 B1	6/2003	Lovenich et al.
6,450,256 B2	9/2002	Mones
6,412,559 B1	7/2002	Gunter et al.
6,024,171	2/2000	Montgomery et al.
5,964,290	10/1999	Riese et al.
5,669,444	9/1997	Riese et al.
5,566,755	10/1996	Siedle et al.
5,501,273	3/1996	Puri
5,470,823	11/1995	Williams et al.
5,417,286	5/1995	Palmer et al.
5,249,627	10/1993	Harms et al.
5,014,788	5/1991	Puri et al.

Canadian Patent Applications

60/252,956	11/2000	Gunter et al.

Other References

Puri, R., King, G.E., and Palmer, I.D., 1991, Damage to coal permeability during hydraulic fracturing, Proceedings of the 1991 Coalbed Methane Symposium, The University of Alabama, Tuscaloosa, May 13 – 16, 1991.

St. George, J.D., and Barakat, M.A., 2001, The change in effective stress associated with shrinkage from gas desorption in coal, International Journal of Coal Geology, 45 (2001) pp. 105 – 113.

Abstract:

Production of methane from coal seams is primarily dependent on the permeability of the coal. The present invention uses a three-step process to stimulate a coalbed methane well, wherein step one comprises injection of a predetermined gas into a well bore intersecting a coal seam, step two comprises a shut-in period and step three comprises the placement

of a propped fracture treatment. In step one, the injection of the predetermined gas physically opens pre-existing paths of weakness in the coal. As the predetermined gas travels along these planes of weakness, it preferentially adsorbs onto the coal and displaces the methane. This displacement process induces shrinkage of the coal matrix which further increases the size of the intervening existing fractures. The second step, or shut-in period, allows time for this gas exchange process to substantially complete, thereby maximizing the effect of matrix shrinkage and enhancement of the intervening fractures. The third step comprises placement of a propped fracture treatment into this enhanced fracture system. Propping of the enhanced fractures ensures that they remain open, even as removal of water and methane work to close the fractures by increasing effective stress within the coals. The result is a stimulated coal seam which maintains enhanced permeability during production operations.

Background of the Invention

1. Field of the Invention

This invention relates to the stimulation of coal seams for methane recovery. Coal seam gas production is primarily dependent on the permeability of the coal seam. Coal seam reservoirs are fractured reservoirs wherein the fractures intervene between essentially impermeable blocks of coal matrix. As the fractures are the only effective pathways for movement of methane through a reservoir to a well-bore for recovery, the size, intensity and connectedness of the fractures determine the permeability and, hence, producibility

of the reservoir. No known method exists for artificially creating fracturing within a coal seam on a reservoir wide scale, so techniques and methods for stimulating coal seam permeability are limited to enhancing the near well bore environment with the goal of effectively connecting the well bore to the existing natural fracture system.

Underground coal seams contain large amounts of natural gas, a significant amount of which is methane. The methane exists in a sorbed state in the coal and several techniques exist for increasing permeability near the wellbore and, hence, methane production. Several challenges exist in creating an open pathway from the coals natural fracture system to the wellbore for the recovery of methane. Firstly, coals are known to possess stress dependent permeability, meaning that the application of additional effective stress upon a coal causes deformation which often closes the fracture system, thus degrading permeability and methane production. A critical challenge in stimulating coalbed methane wells is to design a completion technique that allows the fracture system to maintain an open posture throughout production, thereby minimizing the effect of stress dependence on permeability.

Secondly, the nature of prior art fracture treatment on coals also serves to damage and degrade coal permeability in some regions of the reservoir while simultaneously enhancing it in others. The intent of the prior art is that the enhanced regions of permeability outweigh the damaged areas, with a net positive effect to the near well-bore environment. In a prior art fracture treatment, proppant is entrained within a foam or water-based slurry into newly created and/or existing fractures within the coal seam. As

these fractures are opened, stress is redistributed and other fractures which may be surrounding the opened fracture become pressed shut. This effect degrades the reservoir by diminishing the amount of reservoir effectively connected to the hydraulic fracture treatment. The object of the present invention minimizes this degradation by shrinking the coal matrix prior to the introduction of the propped fracture.

Prior art discloses three main techniques for stimulating coalbed methane wells. All of these techniques disclose injection of a treatment comprising various gases, fluids and/or proppants into the coal seam to fracture the coal.

The first technique is a chemical bath stimulation in which the coals are subjected to various aqueous-borne chemicals to either increase cleat or fracture development within the coals or to change a chemical characteristic of the coals. U.S patent 5,249,627 discloses a method for stimulating methane production from coal seams by treating the coals with various chemicals to improve the removal of water. No disclosures for either gas injection or proppant placement are made. U.S patent 5,470,823 discloses a method for stimulating methane production from coal seams by treating the coals with an aqueous acid solution. No disclosures for either gas injection or proppant placement are made. U.S patent 5,669,444 discloses a method for stimulating methane production from coal seams by treating the coals with various aqueous chemicals to increase fracture development. No disclosures for either gas injection or proppant placement are made. U.S patents 5,669,444 and 5,964,290 disclose methods for stimulating methane production from coal seams by treating the coals with various aqueous chemicals to

increase fracture development. No disclosures for either gas injection or proppant placement are made. None of these disclosed techniques follow the chemical treatments with a proppant.

The second type of stimulation is a one-stage completion technique relying on artificially initiating a fracture and/or propagating an existing fracture through the coals through the application of high pressure injection of gas and/or water based fracturing fluids. Hydraulically fracturing coals is difficult given the plastic behavior of many coals, which tend to fracture at a greater treating pressure than the surrounding strata.

In a one-stage completion, the completion process is one continuous application of pressured fluid, with or without proppant, and the well is placed on production thereafter. No attempts are made to induce shrinkage in the coal. U.S. patent 3,384,416 discloses a method where a refrigerant fluid containing a proppant is injected into a coal seam to create fracturing. The inducement of matrix shrinkage prior to proppant placement is undisclosed. U.S. Patent 6,412,559 B1 discloses method for recovering methane and/or sequestering fluids in coals whereby a gas more strongly adsorbing than methane with or without a proppant is injected into a coal seam, shut in for a period of time from hours to days and released. The inducement of matrix shrinkage prior to proppant placement is undisclosed.

The third type of completion is a cycled gas completion, in which gases are repeatedly injected and allowed to flow back, with the intention of causing in-situ failure of the coals

and thereby inducing fracturing. U.S. patent 5,014,788 discloses a method for injecting a gas into a coal seam which is intended to swell the coals and increase stress within the coal. A rapid depressurization of the coals caused by suddenly releasing the pressurized gas to surface shrinks the coal, removing the induced stress, and mechanically failing the coal. This process is designed to be repeated as many times as necessary. No disclosure is made for following this process with a propped fracture treatment. U.S. patent 5,417,286 discloses a method for stimulating methane production from carbonaceous subterranean formations be injecting a first fluid to sorb into the formation and subsequently injecting a chemically different second fluid to part the formation and relieving the pressure to produce shear failure within the formation. No claims are made regarding the use of a proppant. U.S. patent 5,566,755 discloses a method for recovering methane from solid carbonaceous subterranean formations through the repeated injection and extraction of an oxygen depleted gas. No claims regarding subsequent placement of a proppant are made. U.S. Patent 6,412,559 B1 discloses method for recovering methane and/or sequestering fluids in coals whereby a gas more strongly adsorbing than methane and a proppant are simultaneously injected into a coal seam, shut in for a period of time from hours to days and released. U.S. Patent 6,450,256 discloses an enhanced coalbed gas production system whereby gases are injected into a coal seam and released. The injection of the gas increases methane production displacing water within the cleat system, by affecting the gas saturation within the coal and by reducing the partial pressure between the coal and the cleat system. No disclosure of introducing a proppant after release of the injected gas is made. U.S. Patent 6,571,874 B1 discloses method for extraction of in-situ methane from coals whereby gases are injected into a coal seam, shut

in for a period of time from days to weeks and released. The process is repeated many times with the purpose of creating a propped fracture utilizing fines sourced from the coals themselves. This prior art method contains serious drawbacks. Firstly, fines control is considered a major problem in coalbed methane production, as the fines are known to migrate and plug open fractures, rather than maintain open fractures. As well, the low compressive strength of coal makes it a very poor candidate for a proppant, as the fines would be easily crushed into a damaging powder which would cause plugging. This prior art method does not utilize an introduced proppant after release of the injected gas.

None of the prior art inventions utilize matrix shrinkage in coal and all fail to take into account the benefits of inducing matrix shrinkage first, followed by the placement of a propped fracture.

2. Summary of the Invention

The realization of this object, including advantageous embodiments and modifications of this invention can be seen from the content of the patent claims that follow this description.

The goal of the present invention is to provide a method to stimulate coalbed methane wells. The invention improves on the previously disclosed techniques as it uses the reaction of the coal to the predetermined gas to induce shrinkage within the coal matrix, thus reducing effective stress and enhancing the fracture void volume. This increased

fracture void volume allows placement of proppant within the coals while maintaining open fractures in the regions surrounding the propped fracture, thus allowing the enhanced fracture system to communicate more effectively with both the natural fracture system and the wellbore and aiding methane recovery.

3. Description of the Preferred Embodiments.

The present invention has the advantage that the pressing of the predetermined gas into the coal seam opens the existing natural fracture system within the coal and causes shrinkage of the coal such that when pressure is removed from the system the volume of the coals is less than the volume originally in place. This shrinkage results in additional fracture void volume and serves to create more and better connected pathways through the coal and lessens effective stress.

The object of the present invention is to stimulate a coalbed methane well by injecting a predetermined gas into a well bore that is open to a coal seam, shutting the well in to induce shrinkage of the coal seam and enhancement of the intervening natural fractures and then placing a propped fracture stimulation into the enhanced intervening fractures to maintain the fractures in an open state.

During the first stage injection of the predetermined gas, the gas travels into the fracture network along the fracture planes where it contacts the coal matrix and begins displacement of the methane contained within the coal matrix. This displacement shrinks

the contacted portions of the coal matrix, resulting in an increase in the intervening fracture void volume.

In the second stage, the well is shut in for a period of time to allow the maximum amount of methane displacement to occur. In this manner, the coal is an active participant in the production of induced fractures and planes of weakness, with the interaction between the coal and the predetermined gas creating preferential paths of weakness within the coal. This differs significantly from most prior art fracture treatments which treat the coal as a static medium and attempt to create new fractures within the coal by exceeding it's parting strength.

A second object of the invention is the maintenance of smaller scale fractures in an open posture surrounding the larger scale induced fractures. The second stage shut in period is critical to this effect as it allows the maximum amount of coal matrix to be bathed in the predetermined gas, thereby maximizing the reservoir volume treated for induced fracturing. Once the shut-in period has ended, matrix shrinkage has produced a similar effect to removal of matrix by creating additional void space in the enhanced fractures within the coal seam. This allows the proppant placed in stage three to occupy the enhanced fractures without producing excessively elevated local effective stress fields and collapsing the smaller scale fractures that occupy the region surrounding the propped fracture. In this fashion the propped fracture system maintains an effectively connected posture with both the reservoir's natural fracture system and the well bore and methane collection is enhanced.